

# A TALE OF TWO CRISES

by Dr. Harold A. Zahl

ARMY RADAR HISTORY records that the Fort Monmouth laboratories started their R & D on radio reflection and detection using microwaves in the 9 centimeter band, using the mini-powered magnetron which was available in the early 1930's. But ranges on airplanes and ships were hopelessly inadequate for any military application. High promise of microwaves had years to wait, for it was not until early September, 1940, that the Sir Henry Tizard Mission of Great Britain presented the U.S. with models of their multicavity resonant magnetron, with power potential a thousand-fold greater than early American designs.

Frustrated by the small ranges possible through use of only watt-

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producing magnetrons, in February, 1936, Signal Corps interests shifted dramatically downward to the 100-200 megahertz region of the spectrum, almost the entire laboratory's effort being re-aligned to expand the new technology in a spectrum area where components were available. The idea was to meet the military requirements, and forget the size of the antennas needed to do the job.

As time rushed on toward the Pearl Harbor disaster, it needed no great military genius to sense the threat of the war clouds over Europe, now thundering and raining death, as Hitler's military might moved on relentlessly; or the same across the Pacific, where Hirohito's War Lords were growing increasingly belligerent towards U.S. interests. FDR's crystal ball was ablaze with predicted troubles ahead for our peace-loving nation, troubles both from east and the west.

## The First Crisis

**THE FIRST CRISIS:** Facing this two-edged threat, our military strategists were in complete agreement that the Panama Canal was the most vulnerable spot in our hemisphere. A well-laid bomb in any of the locks, either dropped from the air, or carried in the concealed bottom of some innocent-looking tramp steamer, could raise complete havoc with our ocean-to-ocean shipping, and of course, disastrously upset Navy strategy in how to deploy ships.

The Laboratories at Fort Monmouth had long been involved in seeking ways and means toward meeting threats to "plush targets" such as the Canal. Starting in 1930 the emphasis was on underwater sound since the threat was then mostly from battleships and submarines. For a time, the infrared was stressed, but fog, smoke, rain, or snow were natural barriers. Following dramatically successful tests of 100 megahertz radar in 1937, besides exploiting this new technique for fire-control purposes, we moved rapidly toward applying this technology to the early-warning problem. With enough advance knowledge of an approaching enemy armada, our fighter craft would have enough time to engage them far from their intended target—with ground-based anti-aircraft guns also alerted against those which might have slipped through the outer perimeter of our aerial defense.

Working feverishly on this problem, our initial success was formally demonstrated in November, 1939, when we successfully radar-tracked a flight of high-flying B-17 bombers, from the Jersey coast to the end of Long Island and back—one way,



*It was here, that in November 1939, an historic test was made proving the effectiveness of early-warning radar.*

138 miles. Watching this dramatic display of new military potential were Secretary of War Harry A. Woodring, and Generals George Marshall, "Hap" Arnold and Chief Signal Officer Joseph Mauborgne. Glowingly, they congratulated all concerned, and told military leader Col. Roger B. Colton and civilian chief Paul E. Watson, to move as rapidly as possible in extending this protection to the Panama Canal. On the more personal side, I was particularly proud in seeing how satisfactory had been the operation of one electron tube in the system which I had invented and built with my own hands. With this tube it was possible to operate the system with only one antenna, instead of the two huge ones required without the tube. Later in production, this tube was called the GA-4, and the improved version, the GA-5.

Research and development almost complete, our contractor (Westing-

house) now working day and night, soon had two production sets available. These were rushed to Panama in early June, 1940 (still equipped with my hand-fabricated tube, while industry tooled up to make the 100,000 more eventually required for use in the war to come). The first of these sets became operational within a week after arrival. Sited at Fort Sherman, it over-looked the Atlantic Ocean. The second one was placed on Taboga Island in the Gulf of Panama, on the Pacific side. These two sets were the *very first* early-warning radars in the American defense system. No question—the fear over a surprise attack on the Canal was then much greater than over Hawaii. In fact, it was not until mid-1941 that six similar radars were spotted around the perimeter of Oahu. It was the northern most set, called the Opana Station, which detected the Japanese armada 50 minutes off Pearl Harbor on the

7th of December, 1941, but as history records, the warning went unheeded.

While all our radars were still classified **SECRET**—soon the Panama Canal situation produced a fact of even greater classification—almost **TOP SECRET**. From our own test flights, it was soon learned that high-flying airplanes could be detected 150 miles away or more, giving adequate warning time for defense. Should the planes come in very low, ("wave-hopping" it was called), detection in time for any real defense measures was impossible. Unfortunately, the radar pulse, at the low frequency of 110 megahertz, could not be beamed to follow the curvature of the earth, a point we prayed the enemy did not know. Obviously, a hostile carrier, secretly lurking 100 miles or so off of a Canal entrance, knowing this fact, could easily send in wave-hopping planes with maximum surprise. Yes—all of us in the radar business at Monmouth were truly worried, as indeed were the folk in Washington!

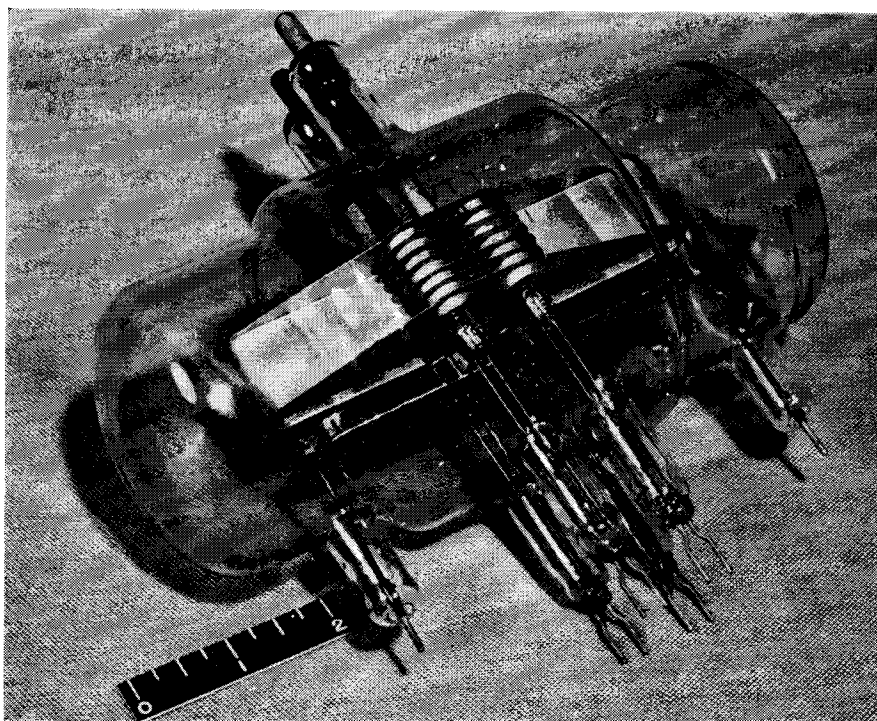
It soon became apparent, not being able to change the Laws of Nature, that the most rapid solution to this dilemma would be to place radar-equipped picket-ships 100 or so miles off of each Canal entrance, thereby extending the warning time of the ground-based stations. Preferably, these ship-borne radars should be small, and of high operating frequency, to enable warning of wave-hopping flights. Unfortunately, to meet this need, an entirely new radar, plus invention in the electron tube field would be required, a point we learned the hard way by first testing everything available we could lay our hands on, including even a British-made set.

### **Idea Nears Success**

About this time, an idea of mine for generating much higher frequencies, started showing some spectacular success. We were closing in on the invention and development of a new and novel design in the world of the electron tube. It wasn't just an electron tube; it was an entire radar transmitter placed in an evacuated glass envelop. Driven by pulsed "lightning bolts" of 20,000 volts, it would produce a peak power output of 250,000 watts, at the then fantas-



*This was the first radar model. Combat experience showed that enemy aircraft could "home in" on the radiation, and both crew and equipment would suffer from their strafing. Later sets were made up with a "separation kit" which allowed destruction of an antenna, but not the operating crew or equipment.*



The so-called "Zahl" tube—VT-158. Pulsed, it gave out 250,000 watts at 600 MHz. This tube was the heart of light-weight early-warning radar TPS-3, and mortar locating set TPQ-3.

tically high frequency of 600 megacycles. A pulse generated by this transmitter could burn through space, probing for one hundred miles at anything which might lie in its path, and by reflected energy, show presence and location—even of low-flying aircraft.

### Research Completed

Our research and development now completed, we turned to industry for production. The final model for mass-production came from a small west coast company owned and directed by William Eitel and Jack McCullough . . . EIMAC, in San Bruno. They called it the "Zahl" tube—the Army called it the VT-158.

Anxiously awaiting for these first factory-made tubes, was one of the Army's most brilliant electronics engineers—John Marchetti. With his team of supporting engineers and technicians, soon he had a radar "bread-board" model available for test. Standing ready for these tests was the first picket-ship-to-be—the trim 125-foot M.S. *Nordic*, docked in nearby Belmar, N.J., complete with crew.

Now at war—because of high secrecy, when at sea with the radar, the *Nordic* would always be escorted either by a Navy blimp or destroyer (or both) carrying depth charges.

We knew from damage to ordinary shipping, that German submarines lurked in coastal waters. One test will never be forgotten. About 40 miles off the Jersey coast, a German submarine surfaced, and its periscope settled on our SECRET radar, but not for long; its view soon included the blimp and destroyer closing in with depth charges. The sub-crash-dived, and may have saved its life—but only because it had surfaced very close to our *Nordic*. Dropping of depth charges had to be delayed, lest they get the *Nordic* too. When the *Nordic* lumbered out to a safe distance, bombs were dropped . . . but no oil slick appeared.

Hitler would have liked that prize!

### Tests Prove Successful

While the tests of this lightweight radar turned out very successful and gave substantial ranges on aircraft flying as low as 15 feet above the water—as we worked on, the pages of the calendar had also been falling. The year 1943 arrived. The threat against the Canal had fallen off to where the picket-ship idea was no longer considered necessary—our Navy was in control of off-shore waters!

Yet here we had a lightweight radar which could be carried by

hand, or easily air-transported, set up and operated by a four-man crew—range on aircraft, 120 miles. The Air Corps became very interested. At their request, on March 1st, 1943, a set was flown to Orlando, Florida, and tested in comparison with three other man-packed equipments. Our set was a winner, and 900 sets were ordered (Zenith), both for U.S. and British use. It was called the TPS-3; and soon the little midget became a global traveler, being at home in all combat theatres of the war—25 of them even crossing the English Channel on a date picked by General Dwight D. Eisenhower . . . D-Day, June 6th, 1944. So my "First Crisis" ends.

### The Second Crisis

**THE SECOND CRISIS:** The scene now shifts to the other side of the world. In the South Pacific, combat was intensifying as American and Allied forces moved from island-to-island—but the cost in human life was great. Well over half of the casualties experienced by our ground troops came from Japanese mortars. Through numerous messages to the States, General MacArthur pleaded for some break-through in technology which would help in the quick determination of the ever-shifting position from which these hell-created torpedo raindrops were fired—generally in bursts of hundreds—and then to a new firing position. But to direct counter-fire, one had to know where the enemy was, and quickly before he moved. Unlike Field Artillery guns which made a big bang, mortars would only make a small puff, inaudible except at close range . . . and the distances were always great, with jungle camouflage adding to the problem. Low frequency radars were no solution to the problem since the small mortar shell was nothing like the target of a big airplane—and in the jungle, small weight and agility were most important.

At Fort Monmouth, mulling over this crisis in the Pacific Theatre, we sweated day after day, leaving no technological stone unturned, as we searched for some potential scientific solution. As I remember, one day a group of us were together, when the murkiness of our combat-oriented atmosphere suddenly showed signs of a clearing. Again it was Marchetti

leading the way. His words went something like this . . . "Harold, your tube works at 600 megacycles and puts out a 'Helluva lot of power.' In wavelength, 600 megacycles is 50 centimeters. Japanese mortar shells are about 25 centimeters long, or about half our wavelength. Electronically, with our frequency, these shells should fairly glisten with reflected energy, if we turned our radar on them. Because of near-resonance with our frequency, perhaps we could get acceptable combat ranges. If we could only detect the shells as they clear the jungle foliage, say a few hundred feet above the firing point, we could easily extrapolate down to where the mortar was firing from. Then we could blast the hell out of them before they could change their location!"

I must have said, "Wonderful, let's get going!"

With this thought, Marchetti and his men left my office and returned to their laboratory. Soon the smell of solder filled the air as a set was made ready for the crucial test—the big question, how much range on a mortar shell? Would it be enough for combat use?

### **TPS-3 Ready For Testing**

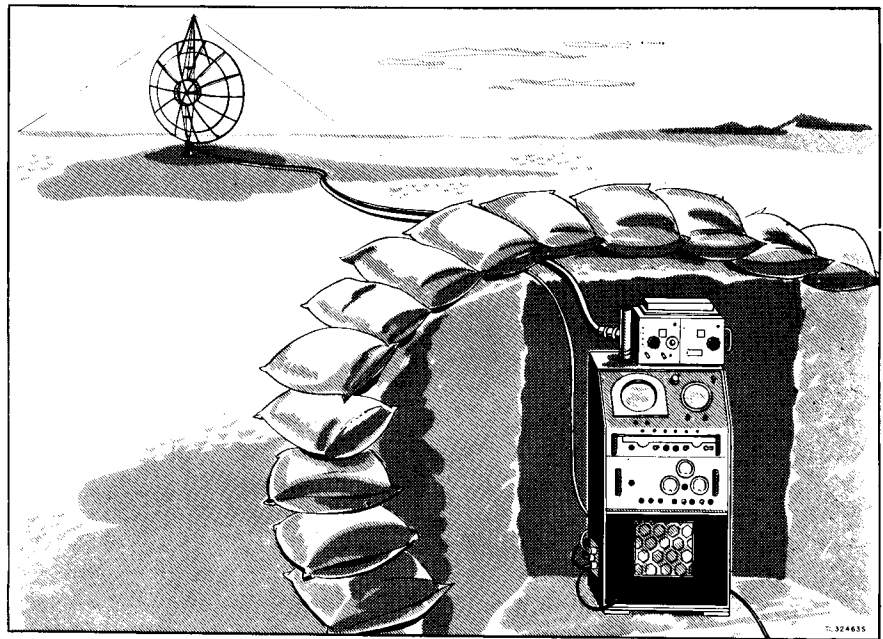
A few days later, Marchetti and I visited Island Beach, a desolate bit of coastline halfway between Fort Monmouth and Atlantic City. The TPS-3 which had been modified was ready for test. Some distance away, an Army mortar crew stood ready to fire shells approximating Japanese dimensions.

The big moment had arrived!

Our radar pointed at the mortar site about a mile away. By radio, the signal was given "Fire when ready." Anxious eyes watched both the radar oscilloscope and the firing site. *THEN*—simultaneously, with the small puff of smoke from the mortar, there appeared a sharp radar "blip" with each shell fired.

The idea had worked!

The rest of the afternoon was spent extending the range between the radar and the firing mortar—the results were spectacularly good; several miles, easily enough for effective combat use. While the calculated positions of the firing mortars were not exact, they were much better than anything MacArthur's



*This pictorial sketch, shows the TPS-3 now modified as a mortar detector, serving as the TPQ-3. The antenna, which cost only a few dollars, was separated from the major electronics and operating personnel.*

men could do with what they had. The only question now was—how rapidly could the modification kit to the TPS-3 be designed, produced, and fielded?

The news of this new breakthrough in mortar detection quickly reached the combat areas in the Pacific Theatre. Through various channels, the word came down of utmost urgency and top priority—even high-level visits by combat officers were suggested, should such serve to expedite delivery. But Marchetti needed no further urging. Overnight, he turned his laboratory into a dedicated group "swearing" to work around the clock, until a first few of the modification kits required could be put into a truck bound for Newark Airport—and then with quick shipment to the Pacific Theatre . . . as industry geared up simultaneously for mass-production.

### **Action Was Everywhere**

Twenty men and a Miss Helena Schroeder starred in the strange bizarre war-time drama. Days and nights passed—a few catnaps, sandwiches, and much coffee. Action was everywhere. Even Helena on the telephone, filled the air with choice phrases, she called out for supplies, food, and the like. When she talked, which was often and dramatically, her vocabulary frequently suggested one made famous by the Missouri mule drivers of World War I;

but she got attention, and results. Bless her! She is now gone; but as I put it later, when she spoke, "The stars and stripes flew violently in the breeze!"

After 96 consecutive hours of activity, a truck came up, and the first modified equipments were enroute on their long trip across the Pacific. The set was called the TPQ-3, going to war, probably with an all-time speed record for conception, production and delivery. No sleeping pills were required for the long rest which soon engulfed this noble group. As supervisor I didn't care if they slept for a week; they had earned it!

As they slept, U.S. industry (Dumont) "picked up the ball." On a crash-basis, 125 more sets were soon in supply channels. Yes, they were warmly received by soldiers far away whose lives might be saved by that miraculous mortar "blip" showing up on their oscilloscopes.

In closing my story, after later use of the TPQ-3 during the Korean incident, together with its parent TPS-3, these two sets were allowed to enter that Valhalla reserved only for fighting radars—radars which had done their job well; losing only one battle to the Dragon who occupies the Cave of Obsolescence. But not so my battle-scarred VT-158 . . . its Valhalla will forever be the Smithsonian Institution in Washington, D.C.

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